Biomass resources in The Netherlands

Wolter Elbersen,
Wageningen University and Research centre,
Department of Biobased Products

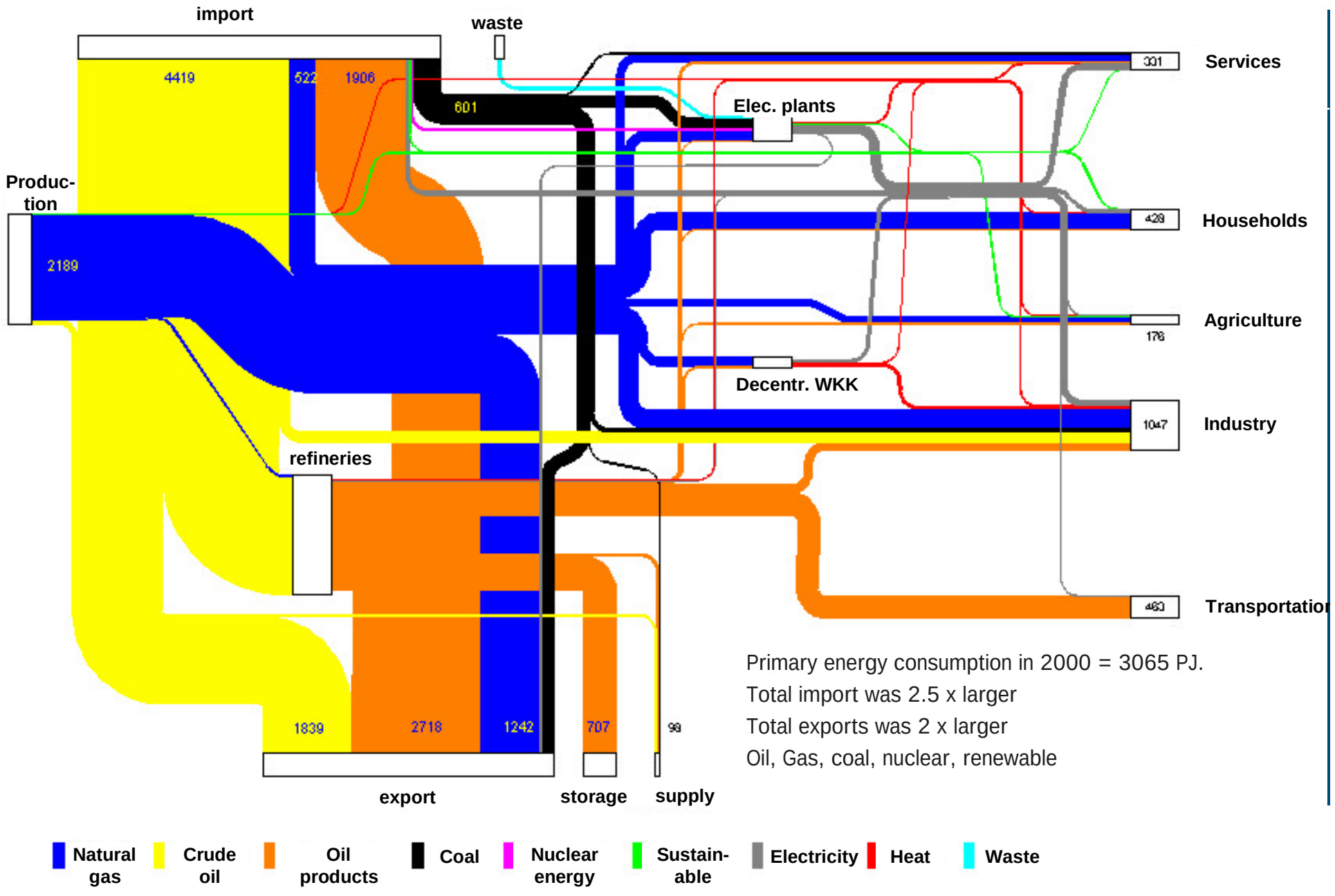
Based on ECN/WUR report: Rabou, L.P.L.M, E.P. Deurwaarder, H.W. Elbersen and E.L. Scott. 2006. A study for “Het Platform Groene Grondstoffen” and financed by SenterNovem.

SenterNovem Den Haag, June 28, 2006

Bioenergy at WAGENINGEN UR

Background:

- A transition has started which has to result in an independent role for biomass and other forms of sustainable energy in 2030
- Vision: In 2030 30% of the fossil fuels replaced by Biomass
- Basic assumptions:
  - Total primary energy use = 3000 PJ in 2030 (equivalent to 2000)
    - 60% replacement of transportation fuels
    - 25% replacement in electricity production
    - 25% replacement of feedstocks for chemicals, materials and products
    - 17% replacement in heat production
- How much biomass is needed?
- How to fit the biomass in the infrastructure?
- Where do we get the biomass from?
- Sustainability and economic realisation discussed indirectly


import
waste
4419
522
1906
601
Elec. plants
Services
331
Produc-
tion
2189
Households
428
Agriculture
178
Decentr. WKK
Industry
1047
refineries
Transportatio
480
Primary energy consumption in 2000 = 3065 PJ.
Total import was 2.5 x larger
Total exports was 2 x larger
Oil, Gas, coal, nuclear, renewable
1839
2718
1242
707
98
export
storage
supply
Natural gas
Crude oil
Oil products
Coal
Nuclear energy
Sustain-able
Electricity
Heat
Waste

In 2000 the primary energy use was 3065 PJ

- In 2000 29 PJ of biomass energy was produced (in avoided primary energy equivalents):
  - Waste incineration: electricity 9 PJ and heat 4 PJ
  - Biomass co-firing (in coal burning facilities): 2 PJ
  - Wood incineration and other: 10 PJ
  - Biogas and landfill gas: 5 PJ
- In 2004 the contribution was 41 PJ
- Bio-transportation fuels were not relevant yet

Fitting biomass in the infrastructure in 2030 (1)

- Primary energy demand of 3000 PJ in 2030 requires extra savings
- Inertia of the infrastructure: The infrastructure cannot be completely written off between now and 2030 and is currently totally tuned to fossil fuels
- 60% biomass in transportation is very ambitious (40% would fit much better)
- 25% biomass in electricity production only possible by complete replacement of a number of base-load power plants on coal or natural gas by biomass plants (co-firing is limited to 10%).
- 25% biomass for chemicals, materials and products is possible. Much development needed.
- 17% biomass for heat through “SNG” (synthetic natural gas). Larger contribution possible

Fitting biomass in the infrastructure in 2030 (2)

- Biomass for the chemical industry has several options:
  - Bio-synthesis gas to replace synthesis gas from natural gas or for FT
  - Bio-ethanol for ethylene
  - Bio-refinery for functionalised chemicals
  - Savings also found in lower need for process energy (20 to 80 PJ)

- Current analysis shows a share of 21,4 as realistic. 30% possible if transportation fuels is 60% not 40% and electricity is 25% not 10% and savings in chemical industry amount to 1,6%.

- Extra input of biomass for heat through utilising process energy or SNG is possible to reach 30% target.

- 23% biomass share requires 900PJ of biomass: 60 million tons DM.
  30% biomass share requires 1200 PJ of biomass: 80 million tons DM

In 2030 the biomass demand is 912 PJ

Sector	Energy demand [PJ]	Biomass fraction [%]	Savings in fossil energy [PJ]	Required biomass [PJ]
Heat	1090	17	184#	240
Electricity	810	12	98	115
Transport	540	40*	212#	353
Feedstocks Metal industry	65	50	33#	47
Chemical industry, natural gas	123	30	37	44
Chemical industry petroleum	315	25	79#	113
Remaining	57			
Total	3000		643#	912

912 PJ is equivalent to 50 a 100 million ton of biomass

Where to get the biomass from?

Method

- What is the gross biomass potential and what is an ambitious but possible net potential in 2030?
- What is gross potential?
  - import – export + national primary production
- Assessment of the biomass streams in 2030 according to category?
  - Primary by-products
  - Secondary by-products
  - Tertiary by-products
  - Specific crop production
  - Imports of biomass

Imports of organic materials (biomass) into The Netherlands in 2000.

	Total mass [kton]	Fraction Dry matter	Mass dry matter [kton]	Energy content [GJ/ton]	Total energy [PJ]
Living animals	200	0,2	40	20	0,8
Meat, fish and dairy	2.995	0,2	599	20	12,0
Living plants	307	0,1	31	16	0,5
Vegetables and fruit	6.381	0,1	638	16	10,2
Grains	6.413	0,85	5.451	18	98,1
Product from flour industry	654	0,9	589	18	10,6
Oil seeds	7.133	0,95	6.776	20	135,5
Fats and oils	2.279	1,0	2.279	30	68,4
Sugar and cacao	1.926	1,0	1.926	20	38,5
Food products	1.952	0,5	976	18	17,6
Waste and by-products food industry	8.946	0,3	2.684	16	42,9
Fertiliser (organic)	200	0,95	190	10	1,9
Wood and pulp	7.010	0,9	6.309	18	113,6
Paper and board	4.092	0,9	3.683	16	58,9
Remaining biomass	1.308	0,5	654	16	10,5
Total *	51.796	nvt	32.824	nvt	620,0

Export of organic materials (biomass) out of The Netherlands in 2000.

	Total mass [kton]	Fraction Dry matter	Mass dry matter [kton]	Energy content [GJ/ton]	Total energy [PJ]
Living animals	398	0,2	80	20	1,6
Meat, fish and dairy	5.028	0,2	1.006	20	20,1
Living plants	1.761	0,1	176	16	2,8
Vegetables and fruit	5.861	0,1	586	16	9,4
Grains	630	0,85	536	18	9,6
Product from flour industry	1.275	0,9	1.148	18	20,7
Oil seeds	1.845	0,95	1.753	20	35,1
Fats and oils	2.237	1,0	2.237	30	67,1
Sugar and cacao	1.856	1,0	1.856	20	37,1
Food products	3.065	0,5	1.533	18	27,6
Waste and by-products food industry	9.310	0,3	2.793	16	44,7
Fertiliser (organic)	271	0,95	257	10	2,6
Wood and pulp	3.462	0,9	3.116	18	56,1
Paper and board	3.880	0,9	3.492	16	55,9
Remaining biomass	1.871	0,5	936	16	15,0
Total *	42.750	nvt	21.502	nvt	405,0

Total primary production in The Netherlands, 2000

Category	Area [10^3 ha]*	Biomass production [ton DM/ha.jr]#	Dry matter Yield [kton/jr]	Energy content [GJ/ton]	Energy yield [PJ/jr]
Transport	113	3	339	17	5,8
Built up area	318	1	318	17	5,4
Semi Built up area	49	2	98	17	1,7
Recreation	89	3	267	17	4,5
Agriculture	2.326	12	27.912	17	474,5
Forest and Nature	483	3,5	1.691	17	28,7
Inland waterways	357	1	357	17	6,1
Water (sea)	417	0	0	17	0,0
Total	4.153	nvt	30.982	17	526,7

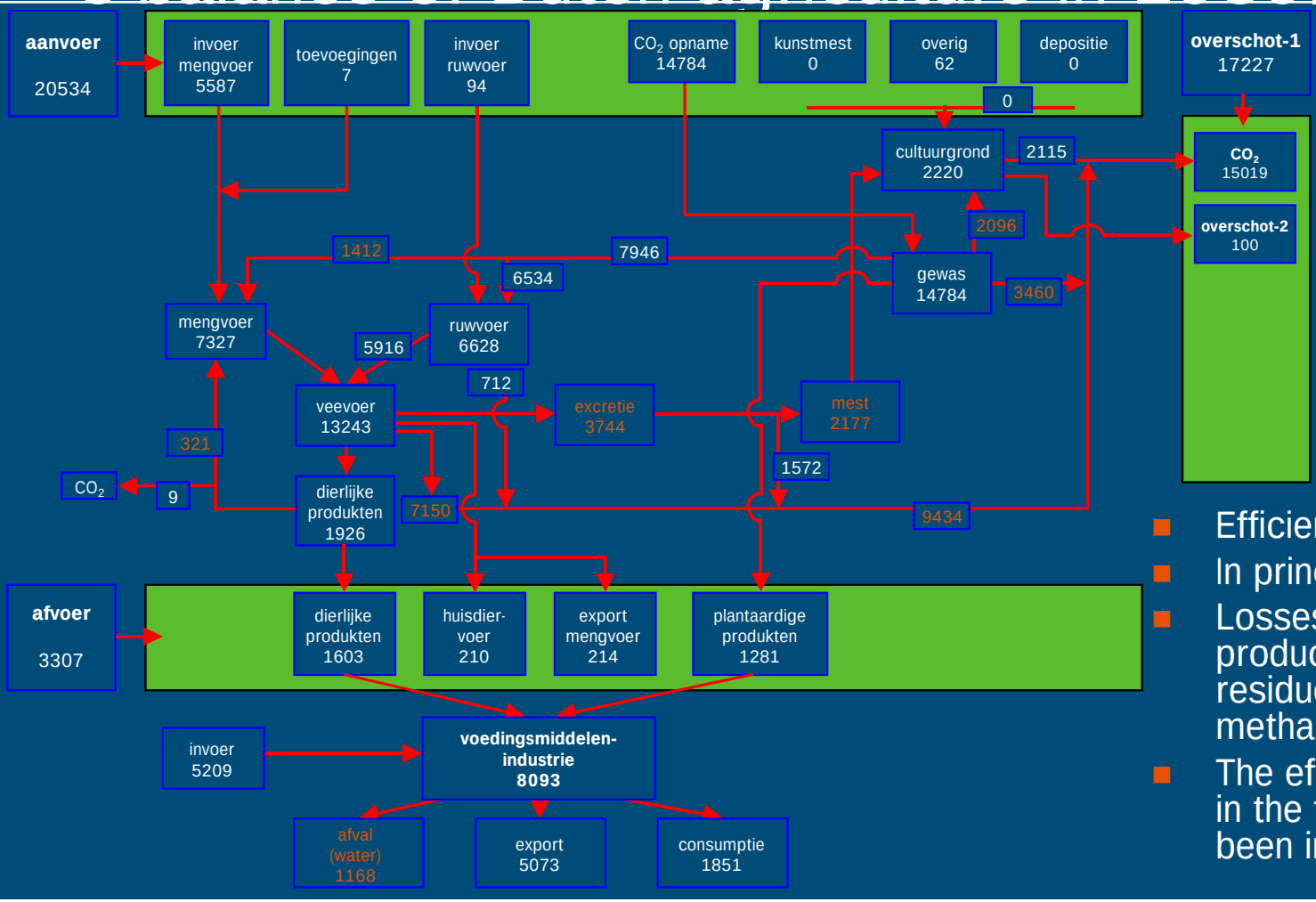
Gross biomass potential in 2000:

- import – export + national primary production

- 32,8 – 21,5 + 31,0 = 42,3 Mton per year
- (Biomass flux is 16 ton DM/ha)

- 620 – 405 + 527 = 742 PJ per year
- =24% of the primary energy use in 2000.

C-balance of Dutch agriculture in 1989.



- Efficiency is 16%
- In principle 84% is lost
- Losses include; manure production, unused crop residues, CO2 and methane,
- The efficiency of utilisation in the food industry has not been included

Bouw, 1996

Which biomass categories?

- Primary by-products: At the source = sugar beet tops, straw, verge grass, prunings, greenhouse residues, etc.
- Secondary by-products, later in the production chain = potato peels, sugar beet pulp, sawdust, etc.
- Tertiary by-products, has had a use = used frying oil, slaughterhouse waste, manure, household organic wastes, used paper, demolition wood.
- Specific crops, rape, energy grain, Miscanthus, switchgrass, SRC, sugar beet for ethanol, etc.
- Imports such as crops, primary and secondary (by)-products

1999, The good old times:

Nederlands vee verorbert negen miljoen ton restproducten per jaar

De Nederlandse veestapel vormt het grootste recyclingbedrijf van Nederland. Van de vijftien miljoen ton voer die het vee jaarlijks verorbert wordt bestaat negen miljoen ton uit restproducten. Ter vergelijking: de gezamenlijke afvalbedrijven hebben een capaciteit van slechts vijf miljoen ton per jaar.

Veel afvalproducten uit de voedingsmiddelenketen komen in het veevoer terecht. Veelal producten waar tijdens of na het productieproces kleine foutjes ingeslopen zijn waardoor ze niet meer aan de hoge kwaliteitseisen voldoen of net niet meer geschikt geacht worden voor menselijk consumptie; foutje in de receptuur, beschadigd, slagroom ingezakt.

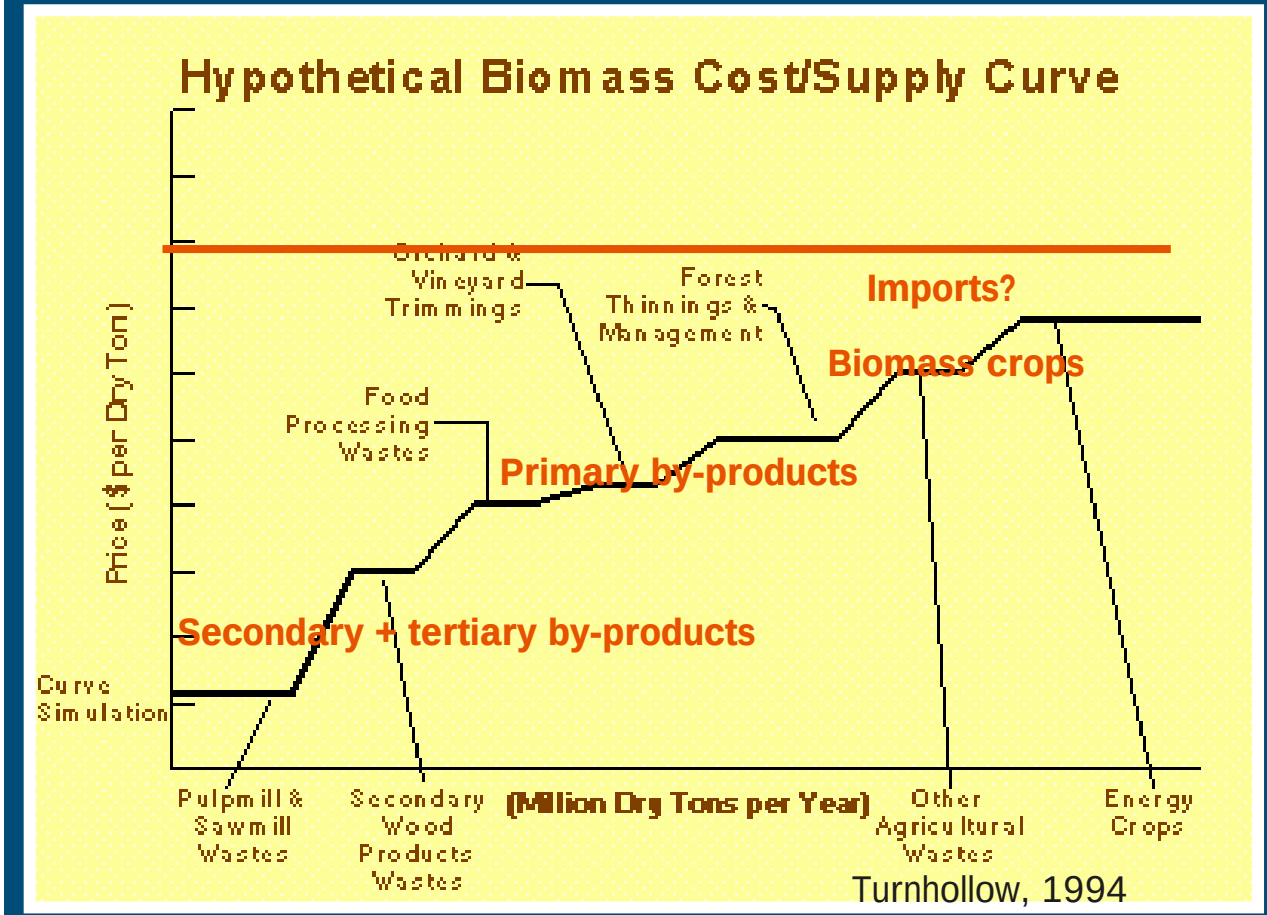
Daarnaast een grote hoeveelheid industriële bijproducten als bierborstel uit de bierbrouwerij, sojaschroot, citrus- en bietenpulp uit de limonade- en suikerindustrie en melkwei.

Er worden ook dierlijke resten tot diervoer verwerkt. Steeds meer zelfs, want de huidige welvarende consument stelt zich steeds kritischer op. Terwijl in ontwikkelingslanden het complete dier voor menselijke consumptie geschikt wordt gemaakt halen wij onze neus op voor in principe eetbare delen als darmen, pens en organen. Waar vroeger ongeveer tien procent van een dier slachtafval was is dat nu al een kwart.

Al die restproducten worden nu via de verwerking tot veevoer weer tot waarde gebracht. Wanneer deze producten allemaal gestort of verbrand zouden moeten worden zou dat de maatschappij anderhalf miljard gulden kosten.

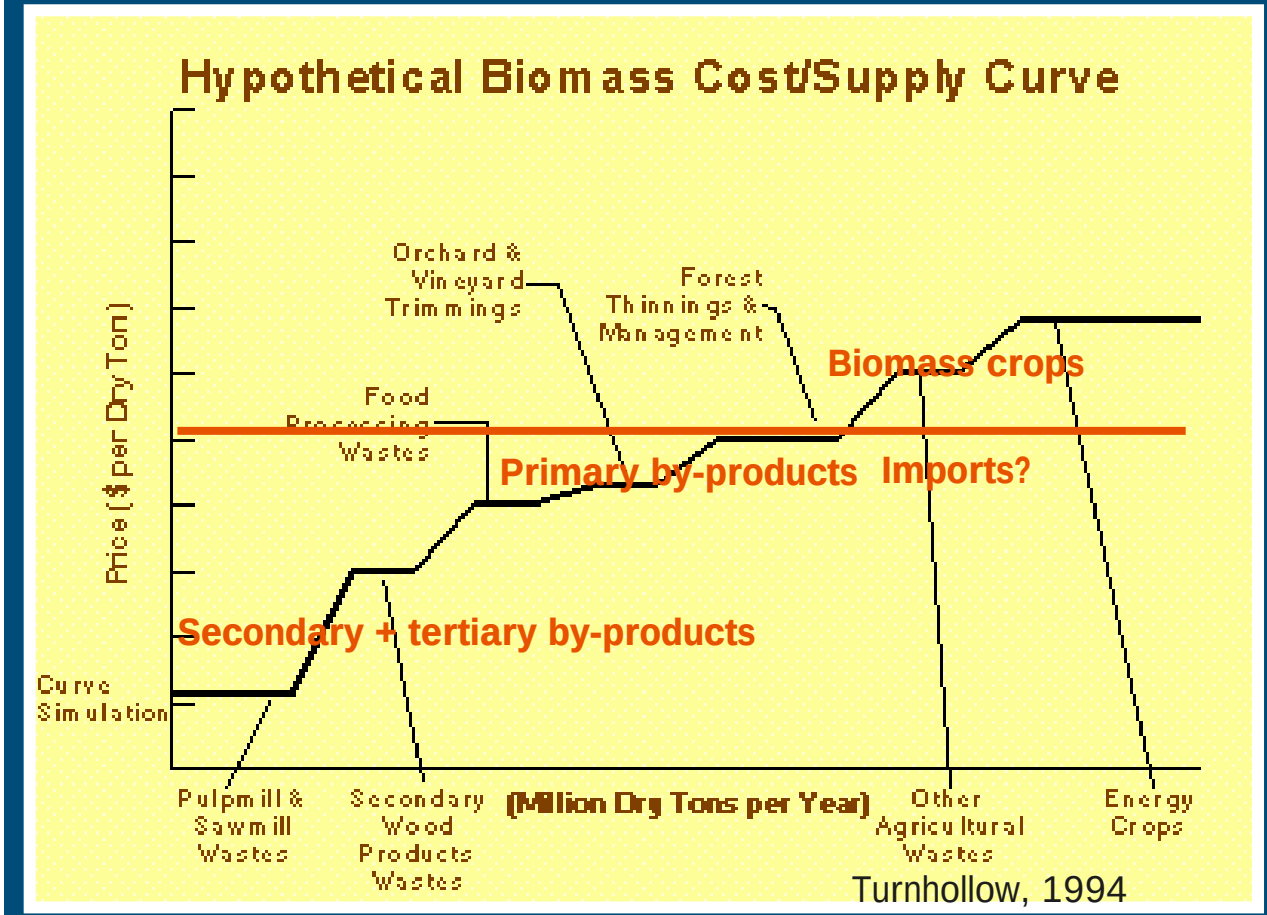
Volkskrant 05/07/99

Byproducts and/or dedicated crops?



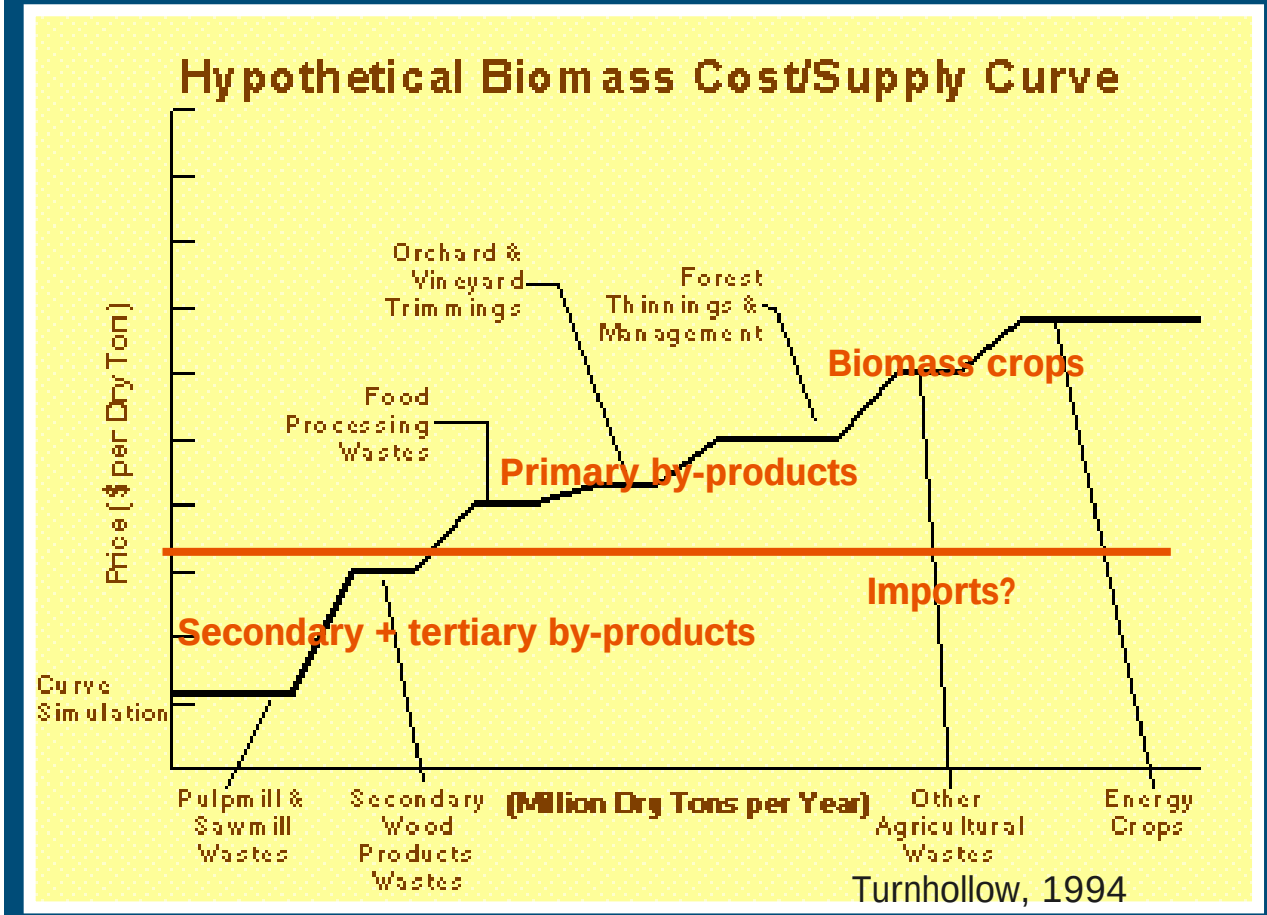
- Tertiary by-products
- Secondary by-products
- Primary by-products
- Dedicated crops
- (Imports)

Byproducts and/or dedicated crops?



- Tertiary by-products
- Secondary by-products
- Primary by-products
- Dedicated crops
- (Imports)

Byproducts and/or dedicated crops?



- Tertiary by-products
- Secondary by-products
- Primary by-products
- Dedicated crops
- (Imports)

Biomass availability in The Netherlands in 2010 (TNO, 2006)

Nr.	Biomassasoort	Aanbod in Nederland [kton/jaar]	Energie-inhoud [GJ/ton]	Energie-inhoud [PJ/jaar]	Prijs [Euro/ton geleverd]	Prijs [Euro/GJ geleverd]
1a	Vers resthout, houtblokken	500	10,2	5,1	10	1,0
1b	Vers resthout, houtsnippers	540	10,2	5,5	18	1,8
2	Energieteelt	2	10,2	~0	80	7,8
3a	Schoon resthout (zaagsel/krullen)	270	15,6	4,2	n.v.t.	0 – 0,6
3b	Houtpellets	100	17,5	1,8	90	5,2
3c	Schoon resthout, afkorthout	250	15,6	3,9	10	1,0
4	Gescheiden ingezameld hout A-hout kwaliteit	500	15,4	7,7	16	1,0
5	Gescheiden ingezameld hout B-hout kwaliteit	700	15,4	10,8	6	0,4
6	Gescheiden ingezameld hout van C-hout kwaliteit	50	15,4	0,8	-74	-4,8
7	Granen	0	-	0	-	-
8	Stro van granen	0	13,3	0	41	3,1
9	Bermgras	450	5,3	2,4	-44	-8,3
10	Hooi van gras	140	12,7	1,8	76	6,0
11	Hennep, vlas	5	11,3	~0	6	0,5
12	Energieteelt (miscanthus)	0,5	13,2	~0	80	6,1
13	Plantaardige olie	4	38	~0	705	18,6
14	Stro	15	13,6	~0	41	3,0
15 a	Schillen	100	16,5	1,7	80	4,8
15 b	Schroot / schilfers	100	15	1,5	150	10
16a	Frituurvet	60	38	2,3	200	5,3
16b	Bleekaarde	12	10	0	-	-
16c	Vetzuren	60	38	2,3	45-125	2,0
16d	Restvetten	0	30	0	-	-
16e	Droge VGI restproducten	100	18	1,8	55-80	3,2
16f	Diermeel	50	22	1,1	0	0
16g	Dierlijke vetten	200	25	5	250	10
17	Swill	215	3,4	0,7	-34	-10
18	GFT[#]	2.280	3,4	7,8	-31	-9,1
19	Afval	10.200	8,4	40	-100	-11,9
20	Oud papier en karton	-	-	0	-	-
21	Textiel	-	-	0	-	-
22	Shredderafval	0	-	0	-	-
23	Reinigingsdienstenafval	0	-	0	-	-
24	Kippenmest	1.000	6,6	6,6	~0	~0
25	Runder- en varkensmest	15.000	-1	0	-16	-
26	Slib RWZI	1.400	1,5	2,1	-	-20 tot -40
27	Composteeroverloop	50	10,2	0,5	-	~0
28	Afgescheiden houtafval uit brandbaar afval	500	15,4	7,7	10	0,6
29	Papierslib	1.000	1,6	1,6	-	~0
30	Papier/plastic pellets (SRF)	2.500	13-20	42	10	0,6
Totaal *		17 Mton		150	-	-
Primair bijproduct (direct van het land)				4,4		
Secundair en tertiair (bijproduct of afval)				143		
Teelt				0,03		
Import				1,9		

WAGENINGEN UR

Total primary production in The Netherlands in 2030

Category	Area 2000 [10^3 ha]	Area in 2030 [10^3 ha]	Biomass production [ton DM/ha.jr]	Dry matter yield [kton/jr]	Energy content [GJ/ton]	Energy yield [PJ/jr]
Transport, and built up area	480	524	1,6	838	17	14,3
Recreation	89	130	3,5	456	17	7,8
Agriculture	2.326	2.004	16,0	32.064	17	545,1
Forest and Nature	483	579	4,0	2.315	17	39,4
Inland waterways	357	498	1,0	498	17	8,5
Water (sea)	417	417	0,0	0	17	0,0
Total	4.152	4.152	nvt	36.172	17	627,8

Lower agricultural area but larger productivity

Primary by-products analysis

- We assume that in 2030 3 million ton DM of crop residues are available (10% of total production):
  - Arable crops produce 2.5 tonnes DM of residues
- 3 Mton primary biomass from outside agriculture (built up area, nature, waterways, recreation area):
  - non-agricultural area produces 4 tonnes of harvestable biomass in 2030
- This will be a total of 6 million ton dry matter equivalent to 100 PJ
- To make these biomass streams available requires investments in infrastructure that can harvest, accumulate, store and process different types of biomass. Dry and wet biomass that becomes available in peaks over the year. Utilising these biomass streams can often support specific environmental goals and can help efficient recycling of nutrients

Secondary and tertiary by-product analysis

- This stream already is the largest source of biomass for energy. The expected supply is 143 PJ in 2010 (TNO, 2006)
- We assume that in 2030 supply will be 200 PJ (12 Mton biomass)
- These streams are already partially used now and will be easier to mobilise than primary biomass by-products. Still, specific investments in an infrastructure are necessary

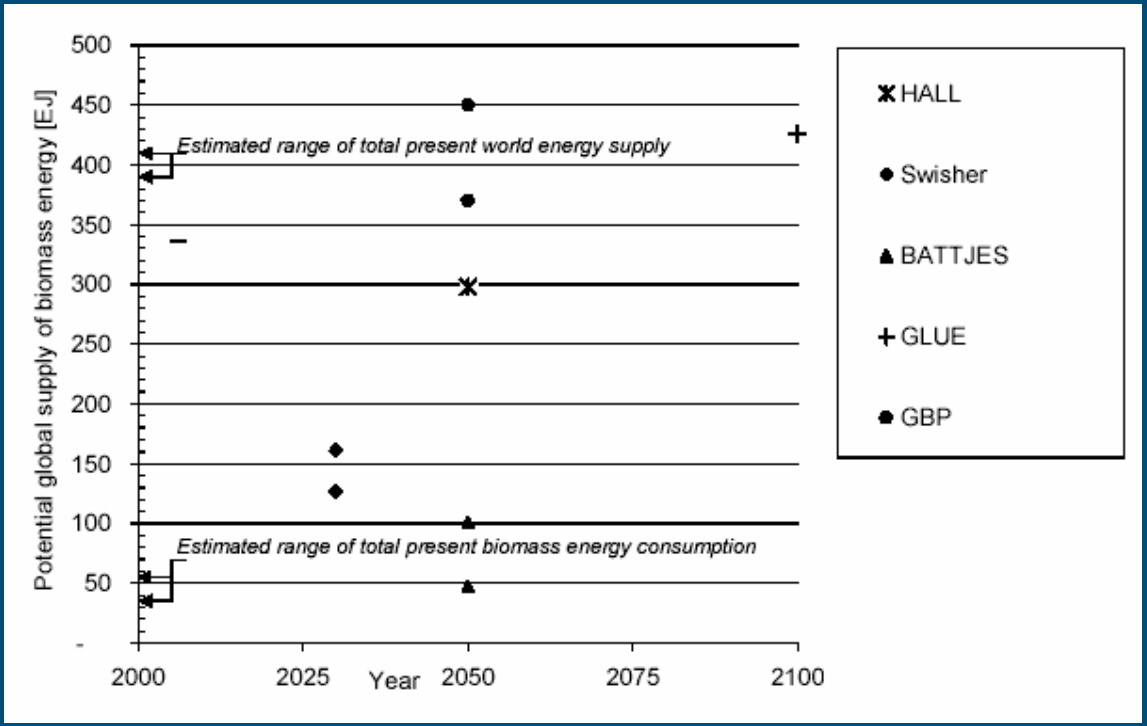
Specific crop production

- Specific crop production for biobased exits:
  - hemp, starch potatoes (50% use for industry)
- Developments to 2030 are hard to predict
  - Strong dependence on changes in the CAP (Common Agricultural Policy)
- Commercial initiatives exist in NL:
  - Oil seed rape for biodiesel (Groningen, Achterhoek en Limburg),
  - Wheat for ethanol production (Zeeland)
  - Energy Maize for biogas
- Other options:
  - Multifunctional energy cropping
  - Biorefinery of crops (grass?): food/feed and non-food
- We assume energy crops can contribute between 0 and 150 PJ (0 to 9 million tonnes) in 2030

Worldwide biomass production

- Global land area 13.2 Billion ha
- 3.5 billion ha grasslands
- 4 billion ha forest
- 1.5 billion ha agriculture
- 4.2 unproductive land
- (In principle 5 billion M ha for food and biomass?)

In total, the upper limit of the bio-energy potential could be over 1000 EJ per year. This is considerably more than the current global energy use of 400 EJ.



Grain, 2004

Worldwide biomass availability

Category	Remarks	Potential bioenergy supply in EJy^{-1}
I: Biomass production on surplus agricultural land	Available area 0–2.6 Gha, yield energy crops 10–20 Mg $h^{-1}y^{-1}$	0–988
II: Biomass production on degraded lands	Available area 430–580 Mha, yield 1–10 Mg ha^{-1} y^{-1}	8–110
III: Agricultural residues	Estimate from various studies	10–32
IV: Forest residues	The (sustainable) energy potential of the world's forest is unclear. Part is natural forest (reserve). Range is based on estimate from various studies	10–16 (+32 from bio-materials waste)
V: Animal manure (dung)	Estimates from various studies	9–25
VI: Tertiary residue (organic waste)	Estimates from various studies	1–3
VII: Bio-materials	This depends highly on demand for biomaterials. Area 416–678 Mha. This demand should come from category I and II	Minus (0) 83–116
Total		33–1130

Hoogwijk et al., 2003

Imports

- Potential is very large: 200 tot 700 EJ per year
- First the secondary and primary by-products!
- The import of biomass is not so much determined by the amount of biomass available (or the gross potential)
- Challenge lies in sustainable supply of this biomass and the associated price

Conclusions

- Primary by-products can deliver 6 million tonnes (100 PJ) per year in 2030 in NL
- Secondary and tertiary by-products can deliver 12 million tonnes (200 PJ) in 2030
- To realise this potential an efficient infrastructure is necessary. All interaction with the (spatial) environment have to be taken into account.

Conclusions

- Specific crop production is more uncertain: 0 to 9 million ton = 0 to 150 PJ
- This means that maximum inland biomass potential is 450 PJ (27 million tons)
- Extra imports op at least 450 PJ are necessary of approximately 30 million tons

Conclusions

- Analysis showed that options for plugging in biomass in the infrastructure is limited by “inertia of the energy infrastructure”. Biomass availability also limited by inertia of the system (agriculture, rules, etc)
- Too often focus is on the demand and the current infrastructure
- One should build an infrastructure that fits the renewable biomass that is sustainably potentially available vs making biomass available just to fit the infrastructure: Match upstream and downstream